DEVELOPMENT OF COMPACT CIRCULAR POLARIZED ANTENNA FOR WLAN APPLICATION

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Sincerely dedicated to my beloved Father and brothers….

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ABSTRACT

Matching the polarization in both the transmitter and receiver antennas is important in terms of decreasing transmission losses. The use of circularly polarized antennas presents an attractive solution to achieve this polarization match which allows for more flexibility in the angle between transmitting and receiving antennas, reduces the effect of multipath reflections, enhances weather penetration and allows for the mobility of both the transmitter and the receiver. Compact circularly polarized microstrip antenna with Circular Polarization (CP) property for wireless communication system at 2.45 GHz is presented. Microstrip patch antennas being popular because of light weight, low volume, thin profile configuration which can be made conformal. Wireless communication systems applications circular polarization antenna is placing vital role. In this study it was applied DGS to produce circular polarization. The single fed circular polarized microstrip antenna is etched on a FR4 with dielectric substrate of 4.3 with the height of 1.6 mm. The axial ratio of approximate 2.1 dB and the radiation pattern results prove that the designed antenna meets the CP criteria. The simulated and measured results show a good agreement and the proposed antenna is suitable for WLAN applications.

ABSTRAK

Memadankan pengutuban pada kedua-dua, antena pemancar dan antenna penerima adalah penting dalam mengurangkan kehilangan penghantaran. Penggunaan antena terkutub bulat memberikan penyelesaian yang berkesan untuk mencapai padanan pengutuban agar dapat menghasilkan sudut antara antenna pemancar dan antenna penerima yang lebih anjal, mengurangkan kesan pantulan berbagai lalun, meningkatkan penembusan cuaca dan membolehkan pergerakan kedua-dua pemancar dan penerima. Antena mikrojalur terkutub bulat padat dengan Pengutuban Membulat (CP) untuk sistem komunikasi tanpa wayar pada 2.45 GHz diperkenalkan. Antena mikrojalur tampal yang popular kerana ringan, kelantangan yang rendah, konfigurasi profil nipis yang boleh disesuaikan. Aplikasi sistem komunikasi tanpa wayar dengan antena pengutuban bulat meletakkan peranan yang penting. Dalam kajian ini, DGS telah digunakan untuk menghasilkan pengutuban bulat. Antena mikrojalur terkutub bulat suapan tunggal dipunar pada FR4 dengan substrat dielektrik 4.3 dengan ketinggian 1.6 mm. Nisbah paksi sebanyak 2.1 dB dan hasil bentuk sinaran membuktikan bahawa antena yang direka memenuhi kriteria CP. Hasil penyelakuan dan hasil pengukurar menunjukkan persetujuan yang baik dan antena yang dicadangkan sesuai bagi aplikasi WLAN.

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LIST OF SYMBOLS AND ABBREVIATIONS

c	-	Speed Of Light
D	-	Directivity
E	-	Efficiency
f	-	Operating Frequency
f_C	-	Centre Of Frequency
f_H	-	Upper Frequency
G	-	Gain
h	-	Substrate Thickness
L	-	Length
L_{eff}	-	Effective Length
R_{in}	-	Antenna Resistance
S_{11}	-	Return Loss Or Reflection Loss(Db)
X_{in}	-	Antenna Reactance
W	-	Width
CP	-	Circular polarized
OA	-	Polarization circular major axis
OB	-	Polarization circular minor axis
ε_r	-	Dielectric Constant
ΔL	-	Extended Length Due To Fringing Field Effect
Γ	-	Reflection Coefficient
RCHP	-	Right hand side circular polarized
LCHP	-	Left hand side circular polarized
PCB	-	Printed Circuit Board
RL	-	Return Loss
VSWR	-	Voltage Standing Wave Ratio

CHAPTER 1

INTRODUCTION

1.1 Background Study

In the age of the new generation of wireless communication systems, high-quality, high-speed data transfer is required, and the size of equipment is decreasing every day, making it ideal for microstrip antennas wireless applications [1]. The antenna polarization is useful when choosing and installing the antenna. For common wireless communication structures can be either linear polarization (vertical, horizontal) or circular. Understanding the differences between polarizations can help users optimize system execution [2,4]. The new era of microstrip antenna design techniques, it was develop and reduced antenna size with wide bandwidth and performance of the antenna. In the transferring station the circular polarization is used in the receiving station so that the direction of the transmitted wave is more effective than the linear polarization. The CP antenna offers more efficiency in both transmission and receiver and better mobility and air permeability than linear polarization antennas [5,7]. To obtain circular polarization with a single feed, the two methods must be emitted with 90 ° phase and amplitude .Since the simple of the microstrip antenna shapes produces linear polarization, it should has several holes design for producing circular polarization in the patch. The disturbance segment is utilized to divide the area into two perpendicular ways with the equal 90 ° amplitude and phase variation. Therefore, the circular polarization specifications are met. It took two orthogonal components to generate a circular polarization. These components must be equal in amplitude, but the phase change of 90 °. The design of the CP antenna is necessary but has some advantages.

Furthermore, in the case of circular polarization, the use of polarization problems is retreated from left circular polarization to right circular polarization .This allows the system to distinguish between signals reflected by transmitted signals [8,10]. These functions realize multifunctional circularly polarized waves for various applications such as remote sensors, radar, navigation system, wireless phone, etc.

1.2 Problem Statement

Advance in wireless communication and future high speed data links demand broadband antenna system. Current microstrip patch antenna technology face narrow bandwidth and high loss performance. Growth of a planar circularly polarized antenna. Even though the oldest and easiest linear polarization antennas (e.g. dipole and monopole) form radiation patterns in all respects, it is more difficult to achieve the same performance as a circularly polarized antenna. The researchers have proposed a variety of techniques, such as using double feed microstrip or inserting several slots on the radiating patch, and all these slots should optimize to confirm that the antenna should be reach less than 3 dB of an axial ratio in the desired design. This project was design of CP antenna based microstrip patch antenna based on low loss and Low cost Substrates material is proposed. In the design process, several configuration are employed to achieve the desired frequency and axial ratio. The antenna parameters will be varied and compared by the measurement characteristics. The scatter parameters will be measured and compared with simulation result.

1.3 Objectives

The objectives of this project are as follows:

I. To design and develop a compact circularly polarization microstrip patch antenna at 2.45 for WLAN application.
II. To fabricate the compact circular polarization microstrip patch antenna and test the performance of the antenna in experimentally
III. To analyse the performance antenna on circularized polarized microstrip patch antenna radiation characteristics

1.4 Scope of Study

The scopes for this project are as follows:

i. The compact antenna operates 2.45 GHz for WLAN application.
ii. To implement various slot configuration, in order to achieve the single resonance frequency band and axial an axial ratio of less than 3 dB
iii. CST software will be used to design and simulated compact circular circularly polarization
iv. The fabrication antenna will be perform and compared the obtained results from CST software
v. The microstrip circular polarized antenna will be tested by using Vector Network Analyzer.

1.5 Organization of thesis

Chapter 1 describes the motivation of this project. The objectives and thesis organizations are presented in this chapter.

Chapter 2 provide a general description of this project and a brief description of the antenna. Specifically, a single-feed microstrip patch antenna. Several polarization and circular polarization antennas will be presented, compared and evaluated.

Chapter 3 explain the propose an integrated single circular microstrip patch antenna model. Detailed simulation and measurement results will be presented, providing excellent polarization performance and significant reduction.

Chapter 4 focus on improving the performance of the project presented in Chapter 3. In this section, a better design with higher gain will be presented. Simulation results and tests will be compared. Basic features such as loss of performance, radiation pattern and gain will be investigated.

Chapter 5 conclude the thesis and give some recommendations for future studies and project development.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

Antenna is a device use to send and receive electromagnetic waves. The microstrip antenna has many benefits over conventional microwave antennas and, therefore, is usually used in several practical applications, more easily of the dielectric substrate. Patches are usually made of conductive materials, such as copper or gold, and can take the form possible. [11]. Microstrip antenna technology has developed rapidly since the late 1970s. Early in the 1980's, basic elements and microstrip antenna arrays were very robust in terms of structure and modelling. In the past decade, printed antennas have been extensively studied because they are superior to other radiation systems such as lightweight, compact and low cost, conformability and possible integration with low-efficiency, narrow-bandwidth active devices however, and these disadvantages can be overcome by intelligent design of the entire antenna [12,13].

Wireless LAN can be utilized both to change wired LAN connection or switching function wired LAN infrastructure. Usually WLAN application can divide in to two types, fixed WLAN base station or access point, and for cellular communications terminals. For base station applications, optimal matching WLAN bandwidth is 1.5: 1 VSWR or approximately 14 dB return loss should be better than. BTS Cellular system Antenna to stimulate circular polarization. It is very interesting, so that it can solve the problem of multi-channel fading. Improve system operation, especially integrated WLAN operation.

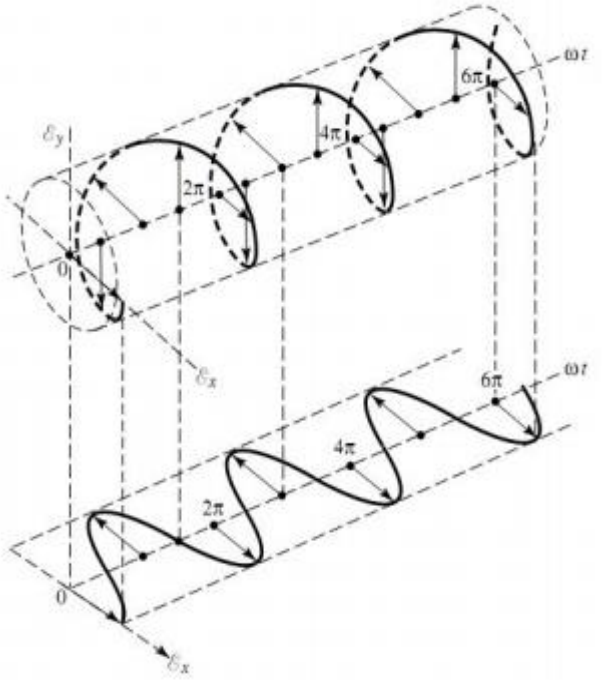
Presently, the most widely used WiFi system is IEEE 802.11b. The system is the need for a WLAN system, which should be fine. Where users are almost invisible. Father more, the microstrip patch antenna is the preferred antenna for WLAN use, since its features are designed to adapt to small areas of the earth and the environment.

Today, wireless LAN (WLAN) applications are widespread. It allow users to provide network facilities without using a wired infrastructure. Point-to-point communication plays a vital role for antennas as it should allow without using wire between the devices. In high performance applications between nodes where size, weight, cost, performance, ease of installation are limited, thin antennas are very common [14].

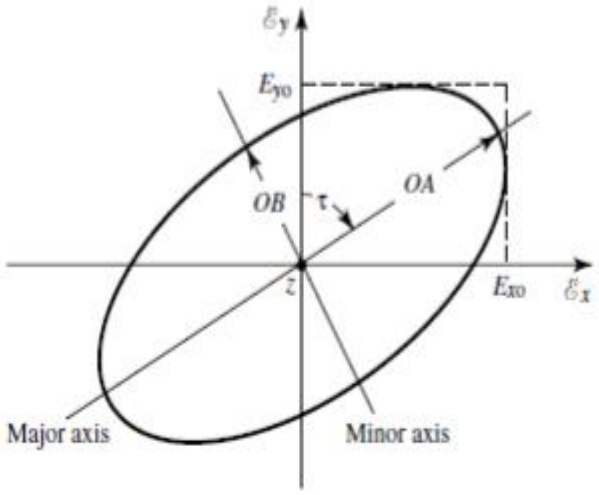
2.2 Polarization

When a wave moves through space, a feature that shows the rotation of different directions as a function of time is called a polarized wave. This is a fixed parameter in of the main beam, but may be different in the small loop. Although both electric and magnetic field vectors are related on the Maxwell equation, it is sufficient to determine the polarization of one of them. And this is usually determined by the electric field. Polarization must be defined according to the IEEE standard in transmission mode. The contours drawn by the tip of the electric field vector emitted in the polarized plane represent the polarization of the wave. Therefore, polarization can be said as a function of time. Figure 2.1 shows the EMW path as a function of time [15]. At any point in the emitted far field, the waves are defined as the intensity waves of the electric E - field are the same as the radiation waves and the dispersion direction is the radial because the distance of the antenna increases to infinity, A few radiation sphere also increases to infinity and strength of decreases. Wave spreading it always looks like a straight wave.

Polarization at any point of radiation in any direction of the antenna it consists such as co-polarization and cross-polarization. Co-polarization is the polarization that the antenna wants to suppress, but the cross polarization is perpendicular to the transmission bias. This is not desirable component.



(a) Rotation of wave



(b) Polarization ellipse.

Figure 2.1: Rotation of a plane of EMW and its polarization.

2.3 Polarization Types

Polarization of radiated wave can be classified as Linear, Circular and Elliptical Polarization.

2.3.1 Liner polarization

In linear polarization, the electrical vector is under all times remain only in one direction. In terrestrial communication linear polarization can further be divided into horizontal polarization where E-field vector is parallel to surface of earth and vertical polarization [16, 17]. The linear polarization antennas are irradiated in a single plane, vertical plane or horizontal plane. The "perfect" linear antenna axial ratio should be 1: ∞. This is the ratio of the horizontal and vertical electromagnetic surface. In terms of linear polarization, the electric field components of the two planes have only vertical components and no horizontal components.

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$$E/_{xo} = 0 \tag{2.1}$$

Polarization is called vertical linear polarization. In this case, as shown in the figure 2.2 the polarization curve can only be seen along the y-axis.

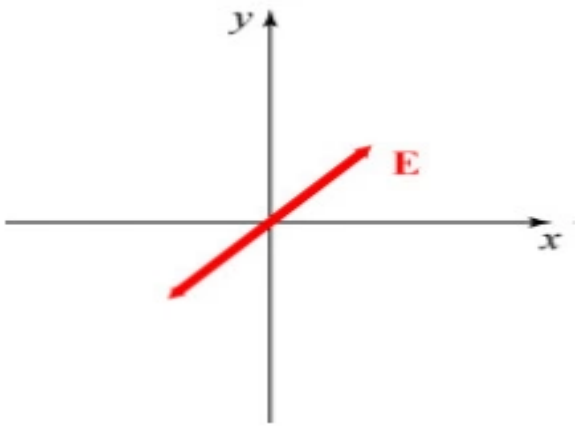

Figure 2.2: vertical polarization.

Also, for horizontal component exist and there is no any vertical component.

$$E/_{yo} = 0 \tag{2.2}$$

Polarization is called vertical linear polarization. In this case, as shown in the figure 2.3 the polarization curve can only be seen along the x-axis.

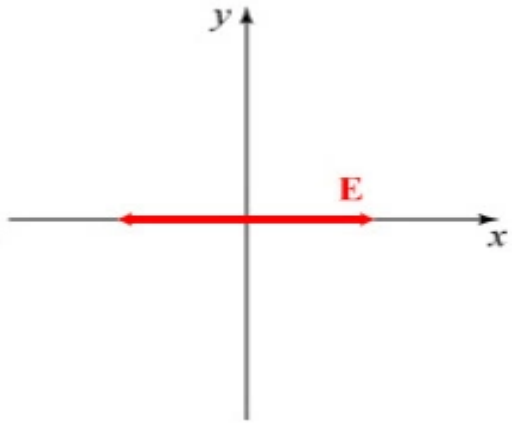

Figure 2.3: horizontal polarization.

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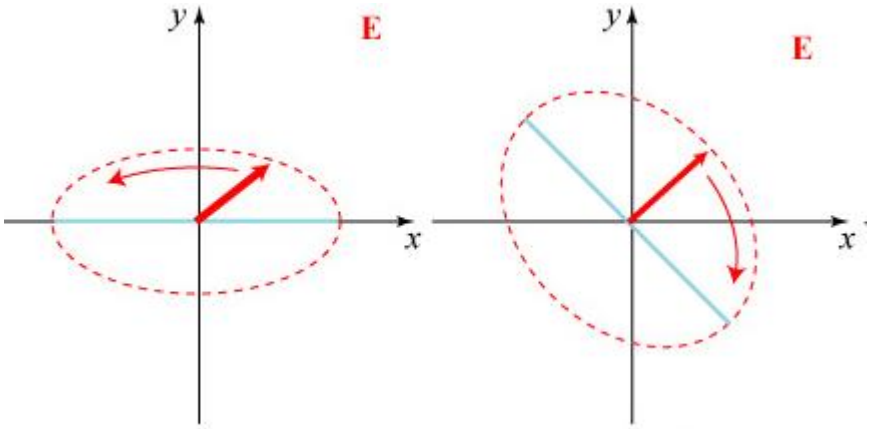
2.3.2 Elliptical polarization

In any point in the radiation sphere, the radiation field component of radiation Follow the ellipse over time and the waves are called to be elliptical polarization. In the elliptical wave is polarized, the two components of the plane component of the electric field show inequality Odd multiple 90 phase different, If the phase difference or phase difference is not the same to integer all 90 [18,19].

The electric field moves the ellipse propagation of the electric field. Figure 2.4 can be divided into two types.



Right hand elliptical left hand elliptical

Figure 2.4: Right elliptical polarization and left elliptical polarization.

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2.3.3 Circular polarization

At any point in the radian sphere, radiation of circularly polarized antenna if the electric field element of the radian wave travels over time. In circular polarization, the two components of the 90 ° plane of the electric field components in the equal field are odd multiple of the phase difference [20]. Since the "perfect" antenna has a 1-axis axis, the polarized plane rotates in a circle shape, rotating completely along the wave. When the electric field reach in peak the way of propagation moves along the stationary circle as time passes. If the polar plane of circular polarized in opposite directions, this is called right circular polarization. This is the right thumb rule where the thumb is directed towards the elongation while the finger rolls in the way of rotation of the electric field. Similarly, if the electric field rotates following the rule of the left thumb or the electric field rotates clockwise, the wave is known as Left hand Circular Polarization (LHCP) [21, 22]. The electric field moves in circles as shown in Figure 2.5. The direction of the circle can be:

- Right circular polarization: the direction of the circle is to the right.
- Left circular polarization: circular direction on the left

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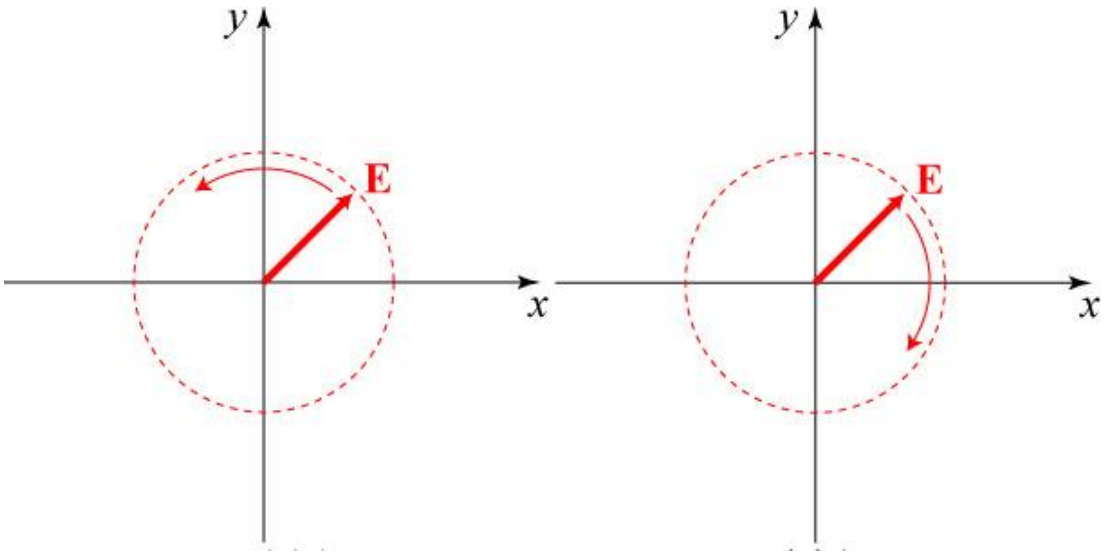

Left hand circular polarize Right hand circular polarized.

Figure 2.5: Right circular polarization and left circular polarization..

2.4 Benefits of Circularly Polarised Antennas

Create two orthogonal electrical field components of circularly polarized. These modules must have the equal amplitude, but the phase is + 90 degrees Figure 2.6 shows (and thus the pole of the Poincare sphere).

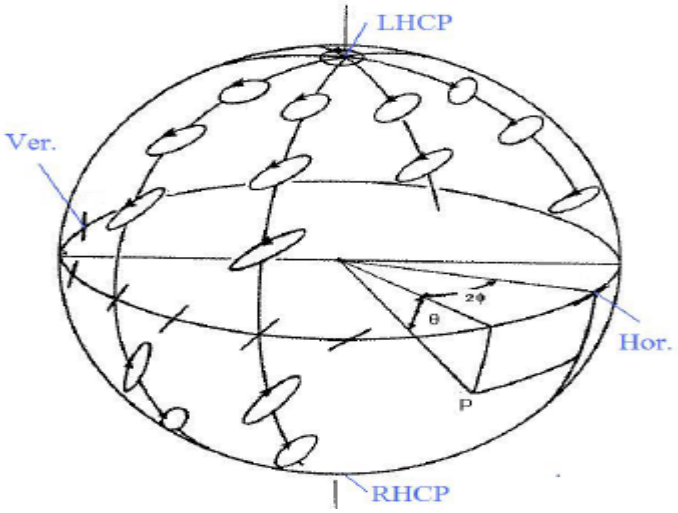

Figure 2.6: The waves from the remote area are above the CP on the left and the CP on the right is at the bottom.

CP antennas demand design but offer multiple benefits:

- **Immunity to Faraday rotation:** Faraday's impact caused a circle of polarized plane. This revolution is related to the component because of the magnetic field, the problem at the top of the earth's atmosphere, Plasma produces a strong magnetic field [23,24]. But it can this area varies depending on many unpredictable factors (e.g. time of day, year, sun activity etc.). This linear polarized would have polarization of the signal may be different. Circular Polarized since the two orthogonal components are the same angle in the size and rotation, it will be affected .That the reason use CP on almost all Earth-satellite communication systems.
- **Mitigation of multipath propagation:** A circular Polarized wave, after reflection from conductor is polarized to a flat surface (This is the correct hand CP, and left-hand vice versa). The antenna allow to reflected signals and is a considerable benefit, especially for satellite navigation systems [25, 27]. It also offers efficiency for high speed communication of data transmission in indoor environments. Because it minimizes and directly reflects the interaction mark.
- **Polarisation losses due to misalignment:** For linear polarization communication the system must receive and transmit the antenna. Adjust the polarisation mismatch. This is not necessary for CP .It should be noted that the ideal CP signal is taken linearly. Polarization antenna, regardless of the direction of the loss is 3 dB, receiving antenna this function is very useful for RFID systems, allows the tracking of mobile labels independently [28].

2.5 Circular polarization and microstrip antenna

Circular polarization in the field of antenna design very popular nowadays, it reduces the significance of antenna path in the plane perpendicular to the way of propagation. Circular polarization (CP) antennas can reduce in many ways and enable data transmission regardless of routing transmitter and receiver. But, it is hard to build a good polarization antenna. Circular polarization is defined as superposition of two linear. Orthogonal phase is excited and has same polarization mode amplitude. The mode for the circular polarization to occur in the two microstrip antennas is equal to the size of the required phase and 90 [29]. Microstrip antennas to ensure circular

polarization, the patch antenna must be modified to fix a circular polarization.The circular polarization is better adapted due to the insensitivity to the antennas used in mobile communications to transmitter and receiver. Circular polarized antennas help in decreasing multipath fading due to the spectral efficiency, impedance, and axial width of the RF system. Although the CP operation is possible with single and double feeding devices, Single fed systems have the advantage of requiring there is no external polarizers or power divider network.

2.5.1 Dual feed circularly polarized microstrip antenna

The most common and direct way to achieve circular polarization is by using two feeding techniques. Both of them modes it may be ready for simultaneous use for the formation of circularly polarized two feeds are in orthogonal position $1\angle 0°$ and $1\angle 90$. As 90 ° phase shift in between the microstrip antenna areas is a condition for circular polarization, the double feed facilitates to create circular polarization in the microstrip antenna. To design dual feed antenna it should choose same patch perpendicular to each other as shown in Figure 2.7. Using an external polarizer, the microstrip patch antenna is fed with the equal amplitude and feed supply. Dual power can be achieved by using a quadrature hybrid, ring hybrid, a Wilkinson power distributor, a T-splicing splitter, or two coaxial power supply with a 90 ° physical phase variation [30,33].

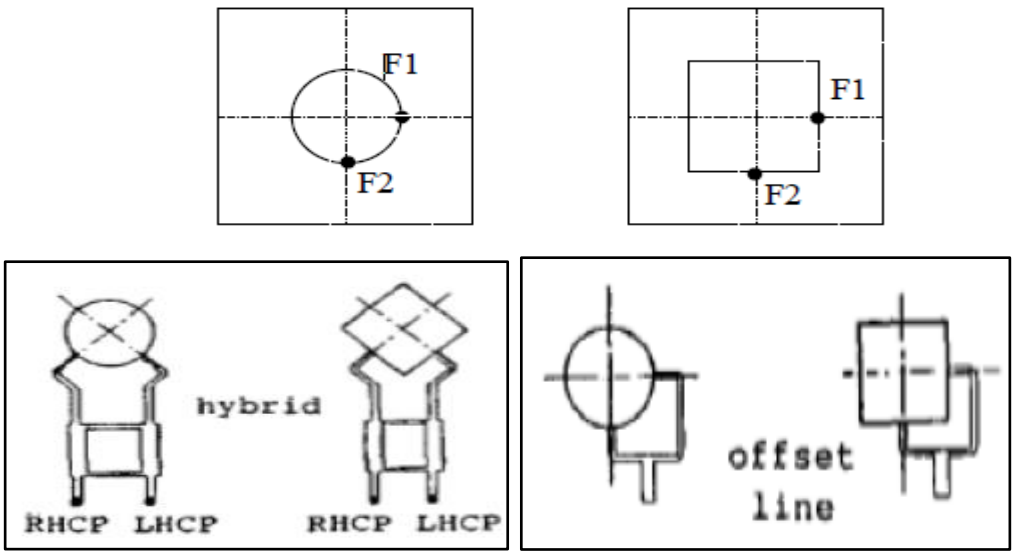

Figure 2.7: Examples for dual fed CP patches.

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